Efficiency of the preparation based on *Bacillus thuringiensis* and nuclear polyhedrosis virus against diamond back moth (*Plutella xylostella*)

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Abstract. Studies have been conducted to assess the effectiveness of bioinsecticide preparation based on the sporocrystalline complex *Bacillus thuringiensis* and the nuclear polyedrosis virus. Before the preparation usage, a significant excess of the economic threshold of harmfulness for the investigated pest was noted on the experimental area of 1 ha. In the first survey of the site, *Plutella xylostella* caterpillar numbers on one plant varied within 5-6 caterpillars range when 62% of white cabbage plants were settled. After 3 treatments with an experimental preparation, the number of caterpillars decreased to 98 sp./100 plants and biological efficiency was 80.4%. Also, the effectiveness of the biopreparation in comparison with chemical insecticides was proved by single-factor dispersion analysis ($F_{obs.}$= 9.05; $F_{crit.}$= 5.98).

1 Introduction

In modern realities of agricultural production, the use of highly toxic biocide preparations remains the main method of combating phytophages. Ecologization of protective measures with the preservation of sufficient efficiency is one of the most important problems of modern vegetable growing. Its solution is of particular importance for the industrial cultivation of white cabbage, the main consumed organ of which is leaves. This is one of the common vegetable crops in Russia and occupies about 30% of the total vegetable area [1].

The most promising solution to this situation may be microbiological insecticidal preparations based on entomopathogenic viruses, bacteria and fungi, as well as their various combinations. Currently, these preparations are considered an inherent part of the integrated plant protection system [2]. Many European countries plan to bring the share of biological plant protection products used up to 25% over the next 10 years [3]. All this suggests the need to find and improve effective biological methods of plant protection, which would allow to obtain high yield of vegetable products while minimizing or full exclusion of chemical treatments.

The diamond back moth (*Plutella xylostella L.*) is a widespread phytophage damaging a significant number of representatives of the *Brassicaceae* family. This pest largely damages not only white cabbage, but also rapeseed, mustard, radish, etc. In Western Siberia, the diamond back moth develops in 3-4 generations. Simultaneously, the development of several

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offspring is observed. Larvae (caterpillars) of various ages bring the greatest harm. They live on the leaf surface, where early age caterpillars skeletonize leaves, and in late development stages gnaw out rounded holes on the lower side of the leaf, leaving upper epidermis intact. Middle-aged caterpillars usually leave the side cabbage leaves and move to the more tender parts of the plant [4]. When using the chemical method, diamond back moth becomes resistant to ever-increasing concentrations of the chemical preparation [5].

With the development of pest resistance to existing chemical insecticides, scientists have expressed interest in preparations based on *B. thuringiensis.* The main factor of this bacterium, which has an insecticidal effect, is Cry-endotoxin. Dissolving in the alkaline environment of intestinal juice, this toxin binds to the affine receptor of the membrane surface of intestinal epithelial cells [6]. Next, there are conformational changes in the toxin molecule, after which it forms a pore or ion channel in the cell membrane, resulting in cell death from loss of homeostasis. After the destruction of the intestinal epithelium, bacterial cells enter the nutrient-rich hemolymph of the insect where they multiply, thereby causing caterpillar death.

Earlier studies on the efficiency of *Bacillus thuringiensis* based bioinsecticides against diamond back moths have significant data spread. The greatest biological efficacy was shown by Entomite BT (*Bacillus thuringiensis ssp. tumanoffi 25*) preparation -92 -94.9%. *Bacillus strain thuringiensis var. thuringiensis 800/15* strain - 80 -90.1%. The spread of biological effectiveness of Lepidocide (*Bacillus thuringiensis ssp. kurtsaki*) in different studies ranges from 51 to 75%. It is worth noting that the consumption of dry forms of preparations per hectare was not less than 1 kg, and in the case of Entomite - 2-2.5 kg. Thus, the search for new strains that have a high pathogenicity to pests with a lower preparation consumption is of great practical importance for replenishing the assortment of microbiological agents [7-11].

The purpose of our research is to study the effectiveness of a new combined entomopathogenic preparation based on *Bacillus thuringiensis* and the nuclear polyedrosis virus against diamond back moth (*Plutella xylostella*) on the crops of white cabbage.

2 Materials and methods

The research was carried out on the basis of a vegetable farm located in the Ordynsky district of the Novosibirsk oblast. The total crops area of the experimental plot was 1 ha. The experiment was conducted on white cabbage hybrids Aggressor F1, Elastor F1, Kolya F1, Rinda F1.

For the treatment of vegetating plants on the experimental site, 350 g of the preparation containing $16x10^6$ spores/g was used. The powder was dissolved in 10 liters of warm water (37-40ºC), then the resulting mixture was added to 190 liters of water in the container of the hinged agricultural sprayer. Spraying was carried out using fine nozzles. The working solution covered 40 -50% of the surface of each plant. Treatments were carried out weekly for three weeks.

A plot of equal area was chosen for control. Plant treatments on control were carried out by insecticides based on pyrethroids, neonicotinoids weekly according to the manufacturers' instructions.

Accounting was carried out visually by counting the number of active specimen on one plant. The plots were examined on two diagonals. 50 plants were inspected on each with a total of 100 plants inspected. Counting was carried out once a week before every new treatment. Biological efficiency of biopreparation was determined by the Abbott formula [12]. The reliability of the obtained results was evaluated by the method of dispersion analysis using Excel program.

3 Results

Primary monitoring of white cabbage crops showed mass settlement of crops by diamond back moth caterpillars. The number of caterpillars varied about 4-6 specimen ($\bar{x}$ = 4.54±0,14) on a single plant with 67% of the heads settled in the studied area. Leaf lesions were characterized by openings ranging from round to oval-elongated shape, some retained the upper epidermis.

After the first treatment with a preparation working solution on most plants, the death of caterpillars of younger ages was noted. The contents of the intestine were dark, indicating the development of *Bacillus thuringiensis* infection, and older caterpillars were characterized by low mobility and decreased appetite (Fig.1 B). No new damage was found on the leaves. However, before the second treatment there was a surge in the number of younger caterpillars due to the degeneration of young larvae from previously laid eggs.

A **B**

Fig.1. Larvae of *Plutella xylostella*: A- before bioinsecticide treatment; B- after.

During the experiments, it was found that caterpillar death occurs within 4 hours after the treatment of the feed by the preparation under study. Caterpillars become sedentary, stop feeding and, as a result, die. The biological efficiency of the preparation in the field conditions was 80.4%. The dispersion analysis also showed the efficacy of the biopreparation compared to the chemical insecticide ($F_{obs.}$= 9.05; $F_{crit.}$= 5.98).

The dynamics of decline in caterpillar numbers at the pilot plot is described by an exponential equation, which is consistent with the classical model of infection spread in populations with high density of specimen per area unit (Fig.2). Whereas, the number of pests at plots treated with chemical insecticides was not much changed. There has even been a small increase in numbers, apparently due to diamond back moth caterpillars resistance acquisition to applied insecticides at the end of the cabbage growing season.

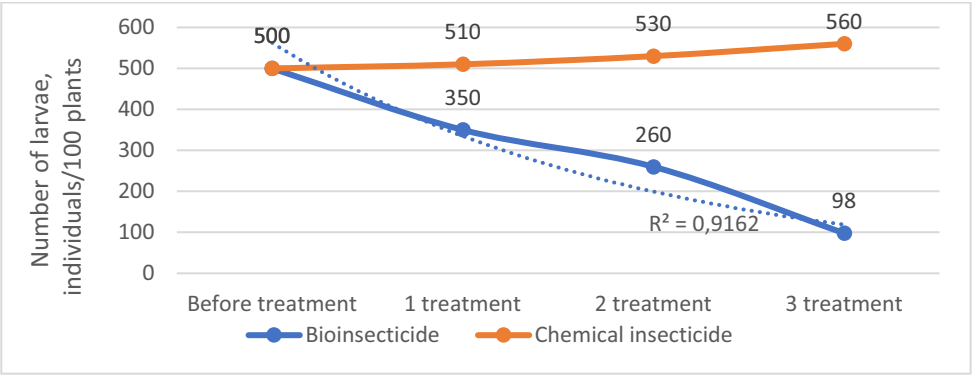

Fig.2. Dynamics of number of larvae *Plutella xylostella*.

Meanwhile, one of the most important indicators of the preparation cost effectiveness is the yield increase when using a particular preparation. The yield data obtained at the completion of plant harvesting also confirm the effectiveness of the biopreparation in comparison with chemical insecticides. At the pilot plot, there was an increase in yields almost 2 times amounting to 127.5 hwt/ha (Tab.1). This indicates high crop preservation with minimal damage by larvae.

Tab. 1. The average yield of cabbage in groups

Experiment option	Yields	
	Averge, hwt/ha	% to control
Chemical Insecticide	57.8	100
Biopreparation	127.5	220.6
HCP_{05}	40.9	71.1

4 Conclusions

1. During the conducted field experiment, high biological efficiency of insecticide biopreparation based on *Bacillus thuringiensis* and nuclear polyedrosis virus (80.4%)) in relation to diamond back moth caterpillars of different ages was established.
2. It was found that the use of bioinsecticide against *Plutella xylostella* significantly increased the yield of white cabbage by 2 times compared to treatment with chemical preparation.

The obtained data indicate the prospect of using this combined preparation on the basis of entomopathogenic bacteria and virus in the industrial cultivation of white cabbage. Reducing the number of treatments with chemical preparations will allow farms to produce environmentally friendly products that are safe for consumers and reduce the pesticide burden on agrobiocenoses.

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